with maneb, significantly reduced bacterial spot and the *P. viridiflava*-induced leafspot (average rating–Table 1). All compounds tested, with the exception of one, did not significantly affect yields in contrast with an earlier report (7).

PV leafspot appears to be a stress induced leafspot. Excessive moisture and/or injury is required for infection and disease to occur. Once the frequent rains and high winds subsided, no further damage occurred in fields where only PV was isolated. However, in fields where bacterial speck was present, considerable damage continued to develop, even after the weather conditions improved. Thus, for disease control, it is important to discern between PV and PST in terms of chemical control. With PV, once weather conditions improved, chemical control would be less of a factor whereas with PST there would be more concern to continue spray applications.

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GROWTH AND DEVELOPMENT STUDIES OF THE TOMATO[1]

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Additional index words. leaf surface, stem mass, root development, fruit size, *Lycopersicon esculentum* Mill.

Abstract. **An assessment of the plant growth-yield relationship of tomato** (Lycopersicon esculentum **Mill. cv. Duke) under commercial production conditions was conducted during 1981-83. A more intensive study of the growth and development of the Duke cultivar was made at the AREC-Bradenton during 1983. Nine measures of vegetative growth and records of 10 fruiting characteristics were made. The following activity peaks in weeks from date of transplanting were stem diameter (12), number and area of leaves (10), weight of plant (11), number of branches (10), axillary breaks (10), number of flower clusters (12), and number of open flowers (11). Root mass increased slowly until week 8 after which time rapid development was noted. Fruit load peaks occurred at weeks 12 and 15 from planting. The data are presented in the family-of-curves format based on regression modeling. This data base should be of value in future crop loss determinations, yield potential studies and cultivar efficiency comparisons.**

Comprehensive stage of growth studies on vegetables can serve many useful purposes. Such information can be used to determine loss levels due to pests, chemical toxicities, environmental stresses or mechanical damage (1, 4, 5, 9, 12). Stage of growth data also contributes to a greater understanding of crop response to cultural systems, comparisons of cultivar performance and assessment of yield potential (3, 6, 10, 11). The data could contribute to a greater understanding of crop growth and to crop modelling concepts, an area of increasing interest to plant scientists, water scientists, and engineers (10). Such information is vital to the development of reliable prediction of harvest date and yield estimates (2, 7). If these studies are implemented on commercial vegetable farms as well as at research centers, useful information can be gained in the characterization of the vegetable industry.

Comprehensive studies on the growth and development of recently released tomato cultivars in the full bed mulch system have not been given much attention in the past decade. This study was initiated in 1978 with 4 cultivars on commercial farms. This report covers only the performance of the 'Duke' tomato on commercial farms 1978-83 and the comprehensive growth stage conducted at the AREC-Bradenton in 1983.

Materials and Methods

Industry studies. Growth and fruit production data have been accumulated for the 'Duke' tomato on 7 commercial farms during the spring in crop years 1978, 1981, 1982 and 1983. All crops were grown with the full bed mulch system, seep irrigated and staked. Fields were selected which fell within a 10-day transplanting period and all fields were harvested within 105 days from setting. Containerized seedlings were used in all fields as were broad spectrum fumigants. All fruit were picked by IFAS workers, ring sized, and graded. At each sampling date, 7 plants at random were severed at the ground line, all fruit removed, plants weighed and stem diameter recorded 1 day before the commercial harvest began. The range of differences encountered in specific cultural inputs is presented in Table 1.

Controlled study. A comprehensive stage of growth study, utilizing the family of curves concept, was conducted on the 'Duke' tomato at the AREC-Bradenton March 18 to June 24, 1983.

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Table 1. Characteristics of production for commercial farms and AREC-Bradenton used in the study of the 'Duke' tomato.

Characteristic	1978-83 Industry	1983 AREC
Distance between beds, average	7.5 ft	4.5 ft
Distance between plants, average	2.4 ft	2.0 ft
Plants/acre	2420 plants	4840 plants
Height of bed, average	0.2 inches	6.0 inches
Linear ft of row/acre, average	5808 ft	9680 ft
Nitrogen applied/acre	283.0 lb.	350.5 lb.
P_2O_5applied/acre	198.4 lb.	100.0 lb.
K_2O applied/acre	525.5 lb.	460.7 lb.
Date of field setting	22 Jan. to 11 Feb.	18 March
Marketable yield/plant	19.5 lb.	17.7 lb.
Yield/acre, 25-lb. cartons	1887.6	3426.7

Containerized 2 x 2-inch, 28-day-old seedlings of the 'Duke' tomato were set into mulched, fumigated beds on March 18, 1983. The Myakka fine sandy soil (Aeric haplaquod series) was maintained at 11% soil moisture throughout the experiment. Mean air temperature and rainfall for the period were: March 69.0°F, 7.4 inches; April 70.7°F, 2.3 inches; May 74.7°F, 1.13 inches; and June 80.6°F, 9.8 inches. Cultural details are presented in Table 1.

All samplings were made at 7-day intervals. Seven plants at each sampling were severed 1 inch from the ground line and stripped of all fruit. All fruit were ring sized. Stem diameters were measured at the severance point. Plants were weighed before all leaves, stems and flower clusters were separated from the plant. The root excavation, leaf area assessment and plant dry weight analysis were conducted on the one, most average plant of each week's sample. All leaves were separated from their main petioles and the leaflets from the compound leaf were laid flat on a 4 x 6-ft plywood sheet which had been covered with a matte white formica and marked off in 4-inch squares. A photographic record was made of plants before and after sampling of fruit, leaf and root displays. Root samples were taken by the nail board method (8), misted and fixed in place on a 2 x 2-inch grid board.

Eleven vegetative factors and 12 fruit development and yield factors were recorded. All data were submitted to regression analysis for non-linear equations using linear, quadratic, and cubic polynomial models. Adjusted r squares were used to test amount of variability accounted for by each model.

The family of curves concept of growth analysis is based on the measurement of discrete organ or tissue development from which regression curves are derived for each component. The component curves are then plotted on an equivalent scale on a background base. The data for the grand curve of growth (fresh weight, dry weight or size) is often selected for this purpose. In general, a series of sigmoid or S shaped curves may be expected.

Results and Discussion

Industry and AREC-Bradenton comparisons. A comparison of vegetative characteristics between the commercial farm (industry) plants and experimental plot of the Duke cultivar is presented in Table 2. The greater top growth noted for the industry mean may be due to the differences in plant spacing, growing period, level of fertilizer applied, and better soil moisture control on most commercial farms.

Fruit development and yield factors are compared in Table 3. The yields were higher in the commercial crop except for number and weight of extra large fruit. The total number of fruit set was 25% greater in the industry 'Duke'

Table 2. Vegetative characteristics of individual 'Duke' tomato plants, commercial crop and research farm comparisons.

Factor or characteristics	Industry mean[z] (N = 72) Mean	Industry mean[z] (N = 72) Standard error	AREC mean[y] (N = 105) Mean	AREC mean[y] (N = 105) Standard error
Fresh weight	9.0 lb.	0.52	7.1 lb.	0.67
Dry weight	1.16 lb.	0.83	0.91 lb.	9.72
Number leaves	170.1	10.50	130.0	9.31
Number stems	5.4	1.10	8.2	0.40
Number sub-branches	10.6	0.50	18.0	2.62
Stem diameter	0.80 inch	0.12	0.62 inch	0.30
Leaf area	101.6 ft²	0.79	58.4 ft²	NA[x]

[z]Mean of 5 yr, 1978-1983.
[y]Mean of 1 yr, 1983.
[x]NA = not available.

Table 3. Yield characteristics of individual 'Duke' tomato plants, commercial crop and research farm comparisons.

Factor or characteristics	Industry mean[z] (N = 72) Mean	Industry mean[z] (N = 72) Standard error	AREC mean[y] (N = 105) Mean	AREC mean[y] (N = 105) Standard error
Number fruit clusters	45.3	3.02	57.5	3.10
Total fruit set	94.4	6.08	70.4	3.92
Marketable fruit, no.	63.0	6.28	54.9	3.70
Immature fruit, no.	29.9	3.92	15.5	1.81
Marketable fruit/cluster	1.4	0.61	0.9	0.11
Total fruit/cluster	2.1	0.13	1.2	0.08
Marketable fruit				
Small, number	9.9	2.26	5.0	1.29
Small, weight	1.7 lb.	0.39	0.8 lb.	0.20
Medium, number	14.3	1.37	15.1	2.10
Medium, weight	3.7 lb.	0.28	3.3 lb.	0.39
Large, number	18.9	2.13	15.4	0.79
Large, weight	5.2 lb.	0.88	3.2 lb.	0.35
Ex. large, number	19.9	3.13	23.9	2.33
Ex. large, weight	8.9 lb.	1.45	9.5 lb.	0.91
Marketable, weight	19.5 lb.	2.18	16.8 lb.	0.96

[z]Mean of 5 yr, 1978-1983.
[y]Mean of 1 yr, 1983.

than it was for the experimental plot. The commercial plants produced 5.2 ft² of leaf surface per pound of marketable fruit, whereas the AREC plants required only 3.5 ft²/lb. Perhaps a closer research look at this relationship would be justified. If growers are indeed creating a larger vegetative mass than is needed to produce a given yield, then appropriate research and educational programs should be considered.

Stage of growth study, AREC-Bradenton. In growth curve studies the 2 most important factors are usually the period in which the growth rate changes from the "lag" phase to the rapidly upturned "log" phase (delta or Δ), and the regression maximum (max) when the curve peaks and begins to flatten out or turn downward. These relationships are easier to detect in graph form than from tabular data. This report is intended to document growth stage data; thus figures are limited due to space and cost restrictions.

Vegetative development factors at the 15 sampling dates are shown in Tables 4 and 5. All but one of the vegetative factors fit the sigmoid curve in Fig. 1, which shows that the number of leaves continued to increase steadily throughout the study. The delta for plant width, height, stem diameter and fresh weight occurred when the plants were 49 days from transplanting. The number of leaves started their rapid increase at the 42-day mark but the development of

Table 4. Plant width, height, fresh and dry weight and stem diameter of 'Duke' tomato plants, AREC-Bradenton, 1983 season expressed on a per plant basis.

Sampling date	Plant width (inches)	Plant ht (inches)	Plant fresh weight (lb.)	Plant dry weight (lb.)	Stem diam (inches)
18 March	2.0	3.3	0.003	0.0004	0.10
25 March	2.4	4.0	0.004	0.0007	0.11
1 April	3.3	5.5	0.008	0.0009	0.16
8 April	5.5	8.7	0.052	0.0048	0.25
15 April	9.2	14.1	0.165	0.0147	0.37
22 April	14.2	22.4	0.363	0.0341	0.44
29 April	19.1	27.9	0.859	0.0727	0.49
6 May	22.1	31.4	2.861	0.1039	0.52
13 May	24.1	33.6	5.507	0.1542	0.54
20 May	25.3	34.8	6.429	0.2467	0.55
27 May	25.8	35.1	6.883	0.3685	0.56
3 June	26.0	35.4	7.070	0.5617	0.58
10 June	25.9	35.1	7.000	0.8018	0.59
17 June	25.5	34.5	6.751	0.9097	0.61
24 June	24.9	33.3	6.277	0.9035	0.61
Linear	**z	**	**	**	**
Quadratic	NS	**	**	*	**
Cubic	NS	**	**	NS	NS

zSignificant at 5% level (*), 1% level (**), or not significant (NS).

Table 5. Number of leaves, branches, laterals, flower clusters and leaf area of 'Duke' tomato plants, 1983 season, AREC-Bradenton expressed on a per plant basis.

Sampling date	Number of leaves	Number of branches	Number of laterals	Area of leaves (inches²)	Number flower clusters
18 March	3.2	—	—	6.2	—
25 March	4.0	—	—	9.9	—
1 April	5.5	—	2.6	79.4	—
8 April	13.5	—	4.3	155.9	0.5
15 April	25.0	—	6.6	325.5	2.2
22 April	39.0	6.0	10.0	930.9	6.0
29 April	55.0	6.6	15.2	2340.5	12.3
6 May	74.0	7.1	22.2	4495.0	20.8
13 May	92.0	7.7	27.1	6203.1	36.5
20 May	105.5	8.0	29.4	7440.0	50.8
27 May	113.2	8.2	28.7	7920.5	55.7
3 June	116.5	8.1	26.1	9765.0	57.5
10 June	117.0	7.8	21.1	8416.5	55.3
17 June	120.0	7.3	18.8	8385.5	49.8
24 June	130.0	6.4	18.0	8223.5	26.0
Linear	**z	**	**	**	**
Quadratic	**	NS	NS	**	**
Cubic	NS	**	**	NS	**

zSignificant at 5% level (*), 1% level (**), or not significant (NS).

branches and laterals, leaf area and flower clusters did not reach delta until the 60th day. Roots spread laterally earlier than the delta for root depth, but root depth peaked 14 days before root spread reached its max.

Leaf stripping, leaf blade lay-out and root excavations are so time-consuming that only 1 plant of each sampling date could be studied. Using the leaf area determination described earlier, the area from 1 plant at max was over 70 ft². The results from the series of weekly root excavations is presented in Table 6.

All of the fruit production curves for the marketable size fruit were sigmoid except for the extra large size (Fig. 2). All sizes from 0.5 to 1.0 inch diameter up through the

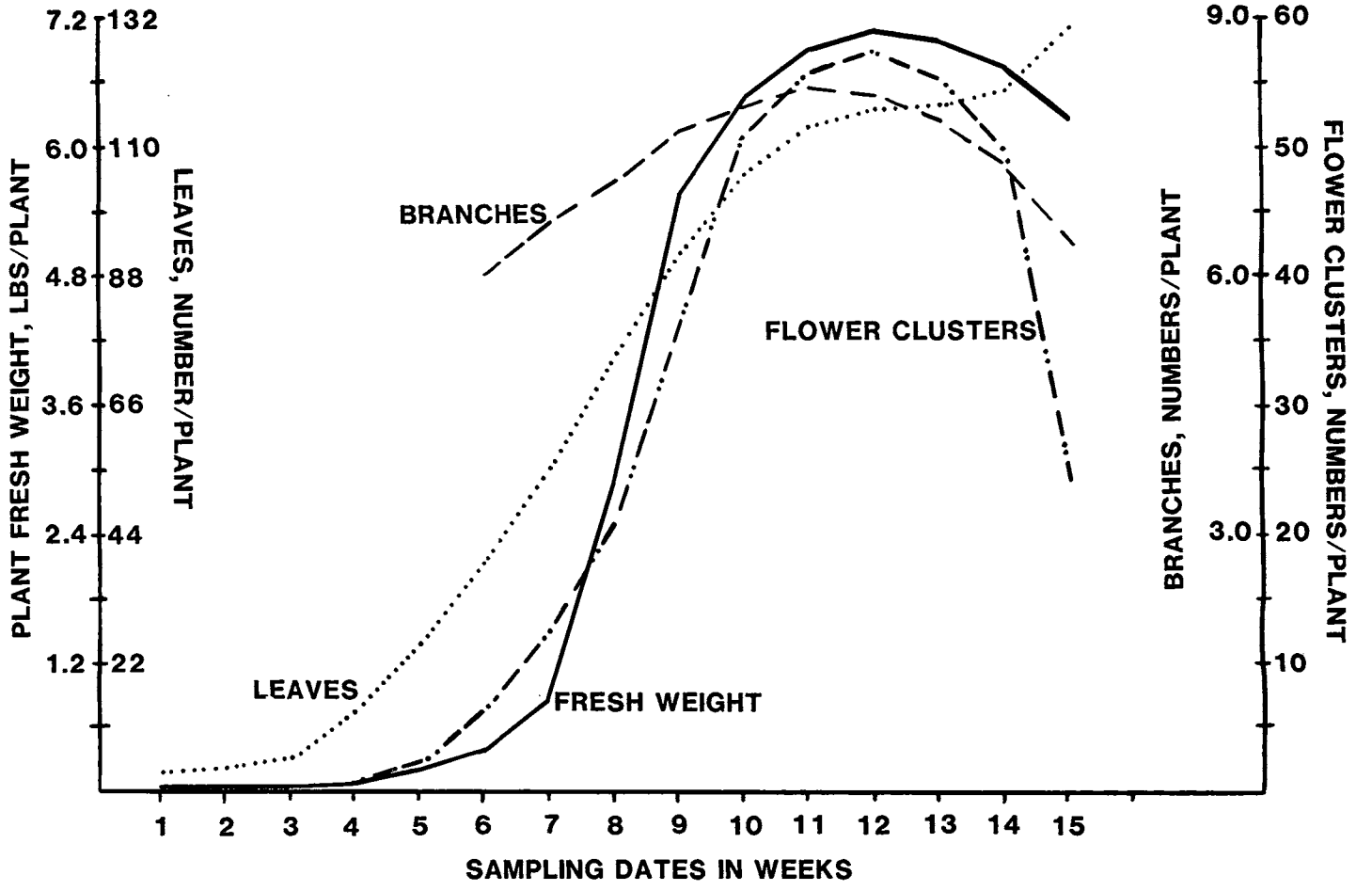

Fig. 1. Relationships among plant fresh weight, leaf, stem and flower production of 'Duke' tomato over the growing season.

Table 6. Root occupation by 'Duke' tomato, full bed mulch, seep irrigated, AREC-Bradenton, 1983.

Sampling date	Nailboard transection display			
	Spread (inches)	Depth (inches)	Concentration (inches)	
			Upper	Lower
18 March	—	—	—	—
25 March	—	—	—	—
1 April	3.0	5.0	0.7	4.0
8 April	3.0	6.0	0.5	4.5
15 April	7.0	8.2	0.5	6.0
22 April	11.0	9.5	0.7	8.0
29 April	11.7	16.0	1.0	12.0
6 May	15.0	18.0	1.0	14.0
13 May	14.0	12.0	1.0	10.0
20 May	15.0	11.0	0.5	8.0
27 May	14.5	12.0	0.5	9.0
3 June	14.5	13.6	0.5	8.5
10 June	14.0	10.3	1.0	6.0
17 June	14.5	10.0	0.5	6.5
24 June	23.5	10.0	0.5	8.0

medium marketable size appear to serve as a temporary pool as they grow into the next size category. The number of fruit per plant recorded at the 10 different sampling periods is shown in Table 7. A partial explanation of the flattening out of the total marketable fruit number is that the pool was becoming depleted and that new fruit set had peaked during the May 20-June 3 period.

The weight of marketable fruit collected per plant at the 7 sampling dates is provided in Table 8. Commercial growers in this production area usually pick only 2 to 3 times and the harvests are cumulative. As a general rule the distribution is about 50-30-20% of the total for the first, second and third consecutive harvests, respectively. In the growth stage study, the harvests probably represent the yield one is likely to encounter in the once-over machine harvest approach. The size distribution in the small (S), medium (M), large (L), and extra large (EL) categories for the industry survey was 8.7, 18.9, 26.8, and 45.6%; for the discrete method of the experimental study it was 4.8 (S), 19.6 (M), 19.1 (L) and 56.5 (EL) %, respectively.

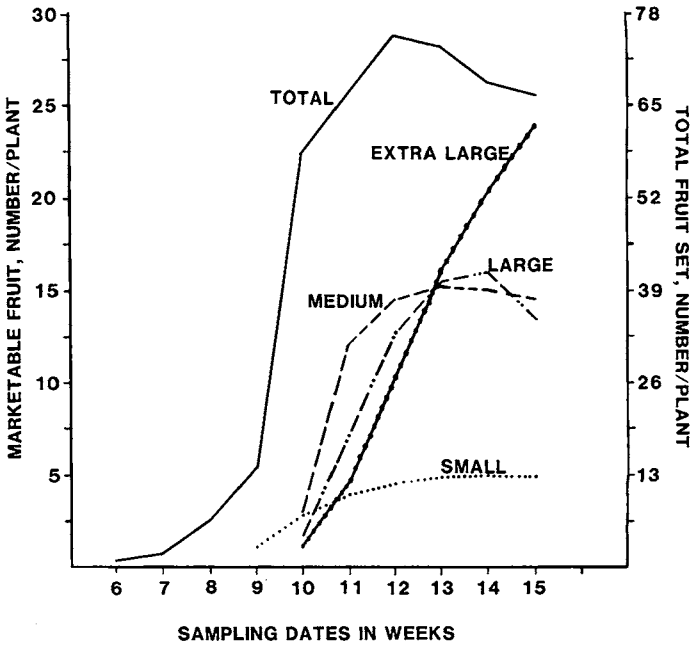

Fig. 2. Change in fruit sizes on 'Duke' tomato plants sacrificed weekly during the season.

Growth stage studies generate a great deal of data, some of which may be of practical use, whereas, most contribute to our crop knowledge base. It is hoped that this study can be continued over several years and, with proper support, valuable supplementary studies can be added. With several years' data, phenological, hydrological and edaphic conditions can be correlated with crop development which could be of great value to the modelling concept.

Much of this information can be used to help determine loss estimates. For example, if chemical or physical damage occurred in a tomato field when the crop had only been picked one time, a realistic estimate of the plant loss, potential yield and total crop destruction might be developed from these data.

Table 7. Numbers of fruit produced per plant, 'Duke' tomato, AREC-Bradenton, 1983 season.

Sampling date	Immature fruit, numbers caliper sized (inches)			Mature fruit marketable ring sized				Mkt. fruit total plant	Total fruit per plant
	0.5-1.0	1.0-1.5	1.5-2.0	Small (no.)	Medium (no.)	Large (no.)	Ex large (no.)		
18 March	—	—	—	—	—	—	—	—	—
25 March	—	—	—	—	—	—	—	—	—
1 April	—	—	—	—	—	—	—	—	—
8 April	—	—	—	—	—	—	—	—	—
15 April	—	—	—	—	—	—	—	—	—
22 April	1.0	—	—	—	—	—	—	—	1.0
29 April	2.1	—	—	—	—	—	—	—	2.1
6 May	4.4	1.0	1.2	—	—	—	—	—	6.6
13 May	6.4	4.5	2.0	1.1	—	—	—	1.1	14.0
20 May	15.7	16.1	18.0	2.7	3.0	1.7	1.2	8.6	58.4
27 May	6.9	13.9	18.1	3.9	12.0	7.1	4.6	27.6	66.5
3 June	4.2	11.8	17.1	4.5	14.4	12.7	10.2	41.8	74.9
10 June	2.6	9.5	9.5	4.9	15.1	15.4	16.2	51.6	73.2
17 June	1.6	6.5	3.8	5.0	15.0	15.9	20.4	56.3	68.2
24 June	1.1	0.4	8.0	4.9	14.6	13.4	23.9	56.8	66.3
Linear	**z	**	**	**	**	*	**	**	**
Quadratic	**	**	**	**	**	*	**	NS	**
Cubic	**	**	**	**	**	NS	NS	NS	*

zSignificant 5% level (*), 1% level (**), or not significant (NS).

Table 8. Production of marketable fruit, 'Duke' tomato, AREC-Bradenton, 1983 season expressed on a per plant basis.

Sampling date	Marketable fruit, ring sized: Small (lb./plant)	Medium (lb./plant)	Large (lb./plant)	Ex large (lb./plant)	Marketable, (total lb. per plant)
18 March	—	—	—	—	—
25 March	—	—	—	—	—
1 April	—	—	—	—	—
8 April	—	—	—	—	—
15 April	—	—	—	—	—
22 April	—	—	—	—	—
29 April	—	—	—	—	—
6 May	—	—	—	—	—
13 May	0.12	—	—	—	0.12
20 May	0.33	.63	.27	.44	1.67
27 May	0.65	1.85	1.96	.56	5.02
3 June	0.88	2.64	3.11	3.51	10.14
10 June	0.95	3.03	3.78	5.73	13.49
17 June	0.84	3.22	4.12	7.89	16.07
24 June	0.68	3.28	4.27	9.51	17.74
Linear	**z	**	*	**	**
Quadratic	**	**	**	**	NS
Cubic	**	NS	NS	NS	NS

zSignificant 5% level (*), 1% level (**), or not significant (NS).

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COLOR AND FIRMNESS OF SELECTED FLORIDA-GROWN TOMATO CULTIVARS

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Abstract. **Color and firmness are two of the more important factors that affect consumer acceptance of fresh tomatoes (**Lycopersicon esculentum **Mill.). However, quantitative measurements of these quality attributes are not readily available for Florida-grown cultivars, thus plant breeders and physiologists have no point of reference with which to compare possible new releases. In this report we present data that characterize color development and firmness in selected cultivars as they progress from mature-green to table-ripe stage. Color is evaluated with a Hunter Lab Color/Difference Meter and firmness is determined by a non-destructive deformation technique. We suggest that these data may be useful to producers, packers, and researchers in the tomato industry.**

Florida's tomato industry is one of the more dynamic agricultural enterprises in the United States. The 1982-83 shipping season covered a span of 37 wk and included over 14 commercially produced cultivars, most of which were marketed fresh (5). New varieties are available each year and, as a natural consequence, growers may have great difficulty in deciding which one(s) they should plant. In fact, the concerned grower may be confused as to what criteria are being used by breeders to determine which new varieties should be released. Two such criteria that are important for consumer acceptance are color and firmness, both of which have traditionally been determined by subjective methods. There have been occasional reports of objective measurements of these parameters (3, 4), but new releases have come and gone so rapidly that it has been difficult to keep up with quality evaluation. Consequently, much of what we know about tomato quality has come from bits and pieces of research. The primary objective of this work is to evaluate color and firmness of several currently produced cultivars and compare these to some "old-line" varieties. This should give some indication of the progress being made in tomato breeding, in addition to providing a point of reference for other researchers with an interest in these quality characteristics.

Materials and Methods

Tomatoes were grown in a variety trial at the University of Florida Horticultural Unit north of Gainesville during the spring of 1983. One harvest was made for each variety between June 15 and June 24. Decayed and defective fruit were discarded and the remaining fruit were graded for uniformity in size (4-5.5 oz), shape, and surface quality. From this lot, 10 fruit were selected to represent each of the following 4 stages of development: mature-green, turning, pink and red. These stages were based on comparison of visual color to a U.S.D.A. visual aid for color classification requirements in grades of fresh tomatoes (8). All fruit were washed, surface sterilized with 100 ppm NaOCl, and allowed to dry prior to color and firmness measurements.

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